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BUILD IT RIGHT: CLEANER ENERGY FOR BETTER BUILDINGS

by Ed Cohen-Rosenthal, Mary Schlarb, and Jennifer Thorne with Adam Serchuk and Don Bradley[1]

*B*uildings leave an enormous environmental footprint, and they determine our comfort and productivity. Growing the market for clean, affordable buildings will require numerous steps on the part of many actors, but it will have a tremendous payoff.

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A Message from the Staff of the Renewable Energy Policy Project

Change comes slowly in the building sector. Buildings themselves, once erected, remain in place, doing what their designers intended, for a long, long time. And buildings matter: our built structures leave an enormous environmental footprint. They also determine their users' comfort, which, in the case of workspace, in turn influences our productivity.

For those reasons, buildings represent an important focus for the sustainable energy field. Using energy more efficiently and relying more on renewable energy generation would bring an appreciable environmental payoff. Moreover, these changes would find allies among Americans who own, live in, or employ people who work in buildings-in short, everyone.

So why is it happening so slowly? As this paper shows, the building sector is a complex, diverse agglomeration of actors, whose complex interests tend to preserve the status quo. There exist few obvious leverage points from which to alter the practices of the whole mass. Changing the building sector requires incremental, simultaneous action on many fronts, culminating in new demand for new products.

We have known as much for years. In one memorable episode in 1989, energy efficiency guru Amory Lovins proclaimed to a group of executives at the Pacific Gas & Electric Co.-including Carl Weinberg, then PG&E's director of research and now chairman of REPP-CREST-that improved efficiency could economically displace 75% of the country's energy consumption. Impressed, and presumably skeptical, they pushed Lovins for evidence. When he conceded that the number was a hypothesis, the utility executives challenged him to prove it experimentally.

The resulting "Advanced Customer Technology Test for Maximum Energy Efficiency," or ACT2, examined commercial and residential sites. Funded by PG&E, the project demonstrated enormous opportunities for saving energy. But before the team approached the 75% target, they encountered a more subtle barrier: rather than simply a technical experiment into efficiency, ACT2 became a social investigation of the practice of building and the professionals who build. For example, energy efficiency measures by their nature interact with each other in an integrated system. The ACT2 team found that changing one component meant recalibrating the others, a complex and expensive prospect for the many contractors who collaborate in isolation on a built structure. In short, changing technology seemed to require institutional change, increased cooperation, and new analytic tools and frameworks.

The struggle continues to incorporate the insights of ACT2 and similar ventures into our buildings, and into the institutions and professions that produce them. It's not easy, as the interview with Don Bradley in this report indicates. But, as Bradley suggests, business niches are opening for builders able to deliver better, cleaner structures. In fact, Amory Lovins contends (in Natural Capitalism, co-authored with Paul Hawken and Hunter Lovins: www.natcap.org) that the transition may be inevitable: sound businesses can no longer afford to neglect opportunities to make money by eliminating waste. We hope so. Meanwhile, we will continue to explore ways to bring home to builders and building users the true environmental costs of their choices, and to explore market development strategies for clean energy industries.

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BUILD IT RIGHT: CLEANER ENERGY FOR BETTER BUILDINGS

by Ed Cohen-Rosenthal, Mary Schlarb, and Jennifer Thorne with Adam Serchuk and Don Bradley[2]

The Chicago Exposition of 1894 ushered in a new age of technology. Electricity played a leading role in the display: visitors rode electrified Ferris wheels and moving sidewalks, Edison lights twinkled in the exhibitions, and a Hall of Dynamos showed off the grandeur of electricity generation. Yet beyond the glow of the fairgrounds, most Chicago residents lit their homes with kerosene and gas, warmed them with coal and wood furnaces, and cooled them—if at all—with air dragged across ice blocks. The dramatic difference between the exposition and the world around it raised Americans' hopes for the future, but also provoked serious questions: Would the poor be able to afford these new inventions? How could rural America benefit from electric power, which had entered the world as a luxury product for the rich? And how could electricity replace the established system of coal, wood, and gas?

A century later we ask similar questions. Newspaper stories describe myriad new energy technologies, model homes, and demonstration facilities and laboratories. The public can read about fuel cells, solar panels, and the like; a lucky or wealthy few can actually use them. But, as in Chicago a century ago, the gap between technological promise and actual practice seems dauntingly wide. In fact, most Americans at the dawn of the 21st century still receive their power from coal-burning power plants, live in houses that waste energy, and use inefficient appliances and lighting.

The vantage point of the past century, in which city homes relied on coal chutes and woodpiles, provides perspective on the coalescing energy landscape of the new century. Take buildings, the focus of this report. They urge us to look farther ahead than perhaps any other consumer product. Consider these facts:

- Buildings under construction today will likely last 50–100 years.
- Energy consumed in U.S. homes will cost $138 billion in 2000, growing to $155 billion by 2020.[3] For a typical household, the annual energy bill is more than $1,300.
- Over the 30 years of their mortgages, homeowners will pay more than $18,000 for energy to run their homes.[4]
- Commercial building owners will spend more than $99 billion on energy in 2000, and almost $107 billion in 2020.[5]
- Much of the energy expenditure for buildings is wasted. Current technologies and practices offer cost-effective opportunities to reduce energy use in new and existing buildings by 30–70%.[6]

As we consider the significance of buildings, two issues loom for the future: the contribution of the built environment to climate change and the awareness of long-term costs and value. Homebuyers should ask themselves what sort of environment they will enjoy in their homes when they pay off their 30-year mortgage note. Governments building bond-financed schools for the next generation of

SOLAR HOMES: TWO NEW PATHS

AN INTERVIEW WITH DON BRADLEY

by Adam Serchuk

Most solar homes, at least in industrial countries such as the United States, have been custom-built as luxuries for the comparatively well-off. Exceptions do exist. In remote locations, photovoltaic-battery systems may represent a cheaper option than grid power delivered over a long distribution line, and solar water heaters may prove competitive even in cities. Nevertheless, most solar homeowners enjoy the discretionary income to pay extra for their environmental principles. Even most retrofit solar systems (i.e., those installed on existing homes) represent an investment by people for whom the high value of solar exceeds its substantial up-front cost.

Solar builders—and the policymakers, advocates, and environmentalists who count on them to deliver environmentally friendly homes to a growing market—must adapt their technology and building practices to broader segments of the public. In the following interview, REPP Research Director Adam Serchuk talks with Don Bradley (Bradley Builders and Developers, and Solar Strategies Development Corporation) about his experience building and selling modular solar homes as well as his work on affordable solar housing in Southwest Philadelphia.

REPP: Tell me about the homes you build. What makes them special?

children ought to ask how today's building decisions will affect those children as they repay the bonds. And because pension funds own or finance so much of the U.S. built environment, young people entering the work force today should ask the professionals managing their retirement accounts what value those property assets will likely have in 50 years—and whether the managers' decisions are making the United States in the 21st century a better or worse place in which to work and live.

PART I. THE PROBLEM: OUR BUILDING PRACTICES

Today's building landscape is dominated by structures—both new and old—that waste energy due to inadequate insulation, poor-quality windows, leaky construction, and poor heating and cooling systems. In addition, these structures damage the environment through reliance on fossil fuels. This does not have to be the case. New approaches to building design, construction, and operation can greatly reduce the environmental impacts and operating costs of new buildings and offer opportunities to improve the performance of existing buildings.

Many builders and environmentalists use the phrase "whole buildings" to describe structures built so as to levy the smallest possible environmental impact while maximizing users' comfort and productivity. With respect to energy, whole buildings draw where possible on renewable resources—for example, through ground-source heat pumps, passive solar design, solar-thermal water heaters, photovoltaic panels, and the like. Most important, however, whole buildings reduce the loads on these generating sources by using energy-efficient appliances, low-emissivity windows, improved insulation, efficient lighting, and other measures. In general, whole building design conceives of buildings as integrated systems of interacting components. The phrase encompasses the materials chosen for a structure, construction techniques, operating procedures, and the ultimate fate of the materials when the building is destroyed.[7]

Throughout this report, we use the terms "green buildings" and "optimized buildings" to describe buildings that are highly energy-efficient and that use renewable energy sources according to whole building principles. Many green building technologies are available today. Homes and commercial buildings increasingly incorporate individual green building components, and some new buildings serve as models for the integrated green building approach. But these cases continue to be exceptions to standard practice in building design, construction, and renovation. Because of the way the building industry operates, there are a number of hurdles to greater acceptance of "green building" by the mainstream building industry.

Overview of the Building Industry

The construction industry makes a vital contribution to social and economic development in the United States, accounting for 7.5% of the gross domestic product.[8] The building sector is also an important consumer of nonrenewable resources, energy in particular. One-third of global primary energy is used just to maintain existing structures and keep them running.[9] The energy embedded in the concrete, steel, processed wood, and so on used in construction materials inflates this figure. According to one estimate, more than half of America's primary energy goes directly or indirectly to serve buildings.[10]

DB: Most of my houses have 16 120-watt BP-Solarex MSX-120 photovoltaic (PV) panels on the roof, for a total peak capacity of 1,920 watts. That capacity may differ with the size of the home. I've done one off-grid home, but the rest have been connected to the local power system through a Trace inverter. The homes also have battery back-up systems in the basement. I'd say that three-quarters have solar water heating (SWH) with gas or electric back-up: two 4" x 8" collectors and a storage tank. In summer, the SWH system supplies about 95% of a family's hot water needs; in winter, about 45%.

But before you even think about how you make your energy, you want to ensure that you're using it as efficiently as possible. We start with passive solar design: the homes face south, so the PV and SWH systems get maximum sun. We plant deciduous trees to the southwest for summer shade (and sometimes vines on the south and southwest faces for the same reason), and evergreen trees in the northwest to block the prevailing winter wind.

Our energy efficiency package includes compact fluorescent light bulbs, energy-efficient appliances, low-emissivity windows, and so on. We try to insulate the walls to R-22 and the ceiling to R-45. We seal the plumbing and electrical outlets so that no outside air gets into the walls or crawl space. We like radiant heating coils in the floor instead of forced-air heat, because you are warming objects instead of air. The shade trees let you downsize the air conditioning system from 2 tons to 0.75 tons of capacity. We use plywood instead of oriented-strand board in the roof because it doesn't heat up as fast, which lowers the air conditioning load as

The building sector consists of large and dispersed groups of businesses and trades with numerous subgroups, each with unique interests and characteristics. From concept to occupancy, constructing a building requires architects, landscape designers, site planners, engineers, contractors, craftworkers, specifiers, project reviewers, interior decorators and bankers—to name but a few categories. (See Box 1.) Considering construction alone, the 1997 U.S. Census of Construction Industries counts more than 5.5 million people employed in more than 667,000 construction establishments.[11]

Why Aren't There More Green Buildings?

Technologies that increase the efficiency with which buildings use energy frequently raise a structure's initial cost, as do technologies that substitute renewable energy resources for fossil fuels. Common technologies in these categories include:

1. windows that reflect sunlight in the summer and allow it to heat the house in the winter, high-efficiency air conditioners and heating systems, insulation; and

2. building-integrated photovoltaic shingles, ground-source heat pumps, solar water heaters, and small wind turbines.

Each of these technologies can reduce the long-term cost of operating a building and can lower dramatically its environmental impact, as well as confer numerous other benefits unrelated to energy use. (See Box 2.) But each requires an up-front investment resisted by many builders and building owners. For builders, however, the primary incentive to include a particular technology is *specification*—the customer's request that a building include such measures. Builders, as they race to meet performance incentives and financier demands, rely on known equipment suppliers and tested techniques and seek to minimize risk.

Several conditions hinder potentially interested builders, designers, and consumers from investing in "green" energy technologies:[16]

Box 2. Non-Energy Benefits of Green Building Technologies

The technologies and practices that make buildings less polluting and more efficient provide a wide range of benefits beyond energy and cost savings.[12] Owners and residents of green homes enjoy increased occupant comfort, improved indoor air quality, reduced noise infiltration from outside and between rooms, less condensation on window surfaces, and decreased fading of fabrics and other materials from sunlight.[13] Commercial building owners and occupants benefit from increased worker and customer comfort, greater worker productivity and decreased absenteeism, improved air quality, and lower maintenance costs. The value of health and productivity improvements is estimated at $30–170 billion a year.[14] Improved lighting systems, particularly those incorporating a significant level of natural daylighting, are increasingly credited with reducing injuries and workers' compensation claims, improving sales in retail establishments, and raising student test scores.[15]

well. Plywood also anchors the bolts for the PV system better. And all the elements form an integrated package: for example, water-saving appliances lets you use your water heater less.

REPP: These energy efficiency features lower homeowners' bills in the future, but add to the price up front. Do your homes cost more than standard homes?

DB: Well, there's a few factors. First, all homeowners spend a certain amount on amenities—things like fancy bathroom fixtures. Our customers channel their amenity dollars into the energy features. Second, I did win funds through the DOE's PV:BONUS program ["Building Opportunities in the United States for Photovoltaics," which seeks to introduce PV into the building sector]. DOE covered roughly half of the extra cost of PV equipment and installation for several homes, which certainly helped. But most important, we compensate for the higher up-front cost of energy-saving equipment by using modular instead of "stick" construction techniques, so that our homes cost the same as a comparable standard home.

REPP: You'd better explain that.

DB: Most homes are "stick" buildings, assembled from scratch with materials delivered to the site. When I started out, I realized that the market for solar homes would be pretty thin, and scattered across a large region. To build stick homes, I would have needed

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BOX 1. THE BUILDING PROCESS FOR HOMES AND COMMERCIAL BUILDINGS

COMMERCIAL BUILDINGS	BUILDING STAGE	RESIDENTIAL BUILDINGS
Owners, *architects*, *and engineers* collaborate on design and overall project management. *Owners* work with *financiers* to obtain project financing. *Owners* approve final construction details, including use of renewables and efficiency measures. In speculative buildings, *leasing agents and tenants* may have input into building design. *State and local code officials* review the design for code compliance. Many *utility* efficiency programs provide incentives to owners at the design phase. Green technologies are most effectively incorporated at this point—changes become more costly and difficult to implement as work progresses.	Design	In production building, *developers* work with *designers* to develop model building designs to be constructed on a commercial scale. It is increasingly common for *contractors* to play a role in the production housing design process. For custom homes, *homeowners* work with *architects and builders* to develop the design for each individual home. *State and local code officials* review housing plans to ensure code compliance.
Owners work with *mechanical and electrical engineers* to specify particular technical aspects of the building design, ensuring that building equipment meets the necessary performance criteria and falls within budget and code constraints. The major energy systems to be used in the building are determined at this stage.	Equipment Specification	*Developers* work with builders (i.e., *general contractors and sub-contractors*) to specify the equipment to be installed in the homes they offer to consumers. *Homeowners* commissioning a custom home work with *builders* to select appropriate equipment for their needs.
Builders (i.e., the *general contractor and sub-contractors*) work with *architects and owners* to translate the design into a completed structure on schedule and within budget. *Builders* install equipment (e.g., HVAC systems, lighting, and building controls). Options for renewable and energy efficiency technologies are determined by *equipment manufacturers* based on the products they offer and their availability.	Construction	*Developers and builders* construct houses according to the design plan. *Consumers* may view model homes to select the design they will purchase. At this point, *consumers* may have input into a limited number of options for building equipment and appliances. *Builders* of custom homes work with *homeowners* to clarify details throughout construction.
Owners and engineers or *independent commissioning agents* may undertake a commissioning process to ensure that the building systems perform according to the design intent and meet occupants' needs.	Commissioning	Not applicable to residential building.
Owners and tenants move into the building and may install additional equipment. Building energy performance is affected by the ongoing actions of *operations and maintenance staff*.	Occupancy	*Consumers* select and purchase their home or move into their custom-built home. Building energy performance is affected by *occupant* behavior.

- *Decentralized building industry:* As noted earlier, the building industry is highly decentralized. Thousands of firms contribute to design, construction, renovation, and equipment installation in buildings across the country. A vast number of companies and individuals require education and training in the concepts and techniques of green building to make optimized buildings the norm.

- *Information barriers:* Builders and consumers often lack appropriate or reliable information about renewable or energy-efficient technologies. The information that is available may not reach the consumer or builder at the right time—when a home or appliance purchase is under consideration. Consumers do not know how much it costs to operate each individual appliance over its lifetime and so do not recognize the benefits of upgrading the most energy-intensive equipment. Many consumers consider only the first-cost of an appliance in choosing the "best buy" for their dwelling.

- *Institutional relationships:* The proper sizing, installation, and use of many green building technologies requires coordinated effort from contractors responsible for different building systems. For instance, efficient lighting may lower cooling requirements. Yet the design process does not provide adequate communication among the different parties involved in the construction of a building, particularly because tasks are segmented and assigned to specialists. Consequently, building systems often remain unintegrated, and fail to provide maximum energy and cost savings.

- *Split incentives:* The builders, landlords, buyers, and installers who make decisions about the structural components and equipment used in buildings do not pay the operating costs for the building. However, they do have an incentive to minimize first costs. Thus, a split incentive exists between these decisionmakers and the ultimate building owners and tenants.

- *Transaction costs:* A bevy of transaction costs combine to emphasize speed in the building process, increasing builders' wariness of unfamiliar solutions. For instance, interest rate fluctuations threaten building projects designed to be economically efficient at a particular rate. Adding to the pressure, builders rushing to prepare a structure for occupancy to avoid the expense of maintaining unoccupied or uncompleted buildings often substitute readily available, likely cheaper, less-efficient equipment.[17] Finally, project reviewers must consider projects quickly, with minimal mistakes, and are therefore less comfortable with new and innovative designs.

- *Financial barriers:* Consumers and businesses, particularly homeowners and small commercial enterprises, often lack the capital to construct more-efficient buildings or buy better appliances or to invest in building improvements or retrofits. The first-cost barrier to optimized buildings can be an enormous hurdle for these consumers. While numerous finance programs are potentially applicable to some green building technologies, few are easy to identify or use.[18] Without consumer demand, the building industry will not design, construct, or install green building components.

- *Energy costs:* Given the overall costs of owning and operating a home or business, energy costs are often a small part of the total budget. As a result, many consumers do not pay much attention

to educate too many people in too many different places—architects, framing crews, and so on. Besides, stick building takes too much time.

But while doing the research to start my solar building firm, I learned about modular, or factory-built, homes. Modular homes are inherently less expensive—5–7% less than equivalent stick-built homes—because the factory buys the sticks in bulk, and cuts them to fit and assembles them on an assembly line. Modular homes also cost less because they create less waste: the factory uses computer-aided design to cut each piece of plywood or piece of two-by-four into pieces most efficiently. It's like the sheets of balsa wood in a model airplane kit: everything nestles side by side. And with a modular home, I have less waste at the building site. I can throw practically all my construction waste away in a plastic garbage bag, so I don't pay large dumpster rental, waste transport, or landfill tipping fees.

The other big advantage of modular homes is time. It takes three to nine months to build a conventional home, with the interest charges accruing. I can build my homes in 30–45 days! That's several months of interest the customer doesn't pay on the construction loan—which increases the opportunity for a client on a fixed budget to purchase amenities or extra energy efficiency features for their home.

At any rate, I immediately saw that less-expensive modular construction would compensate for the up-front expense of the solar components. Or at least I stumbled on that idea and it turned out to work!

to energy. A lack of interest from consumers translates into a lack of action from the building industry.

In short, the fragmented nature of the building sector leads to tremendous inertia. A host of barriers reinforce this condition, and make it even less likely that green building will become the norm in the absence of a concerted strategy.

PART II. THE GOAL: MAKING EFFICIENCY AND RENEWABLES STANDARD PRACTICE

If we are to shift away from carbon-based, depletable fuels to renewable energy over the next 50 years, comprehensive and effective policies will be needed to transform the market for clean energy and energy-efficient technologies and practices. This transformation will require policy and program initiatives targeting the full array of individual and institutional actors and barriers influencing energy use in buildings. Each of the barriers to greater use of green building techniques must be addressed with complementary policies to make energy efficiency and renewable energy the norm.

In the end, however, a key driver of a market transformation for green energy technology will be scale. Greater sales volume will bring greater familiarity and lower prices, which in turn will accelerate deployment. Cost reductions will come from larger manufacturing facilities, larger production runs, and continuous improvement in technology in the competitive marketplace. As several analysts have observed, renewable energy and energy efficiency technologies are manufactured technologies, and are particularly amenable to economies of mass production.

Scale brings economies from corporate learning, as firms discover how to make their products more efficiently, with fewer flaws and less energy. This is the well-known "learning curve," by which firms' accumulation of experience with specific technologies correlates directly with cost reductions.[19] Finally, scale will lower transaction costs. As clean energy technologies become ubiquitous, they will become invisible. Builders will be able to install them as modular elements of a building, and users may eventually pay as little attention to them as we do today to the sprawling electric grid massed behind our wall sockets.

Three other mechanisms will reinforce the effects of scale. First, the emergence of clean, comfortable and environmentally *optimized buildings will make conventional structures less desirable to consumers*. Today, few consumers would choose to have a coal chute in their garden or a boiler taking up their entire basement because better options for heating buildings are readily available. By the same token, when buildings with renewable energy systems are as comfortable (or more comfortable) and as cheap (or cheaper) to own and operate as conventional buildings, the market should respond. And investments in energy efficiency and renewables will increase the appraised value of these properties.[20]

Second, it is *less expensive to build in renewable energy and energy efficiency technologies initially than to add them as retrofits*. Even assuming, as we do, that scale will eventually lower initial costs and improve performance, the higher cost of adding technologies to a building later in its life argue in favor of foresight and early entrance. Further, building-integrated technologies that accomplish multiple functions on walls and roofs for structural and electrical purposes lower installation cost. For example, if color-coordinated solar panels

REPP: What is the construction process like?

Most of my homes actually have been custom-built, in one sense of the term. I sit down with the customers and we decide what kind of house they want. Basically, I "solarize" their vision of what they want. Then I deliver the specifications to the factory. It takes me a day to dig the foundation, the next day to lay six inches of crushed stone, and one day to set the basement walls, which arrive at the site as pre-cast steel-reinforced concrete sections.

On the fourth day, I have a crane and a subcontracted "set crew"—trained and authorized by the factory—ready at the site. The factory delivers the parts of the house. We unwrap them, crane the pieces into place and bolt them together. We install the solar equipment on the roof while it's still lying flat on the ground, which lowers our labor for that task from about 4 or 5 person-days, to about half a person-day! I think I'm the first builder to do that. By the end of the fourth day, the house is up, and under lock and key. From that point, it takes us as long as a conventional builder to finish the inside, but we're already way ahead. Plus, we avoid the theft, vandalism, dirt, and weather damage that conventional homes undergo during the construction process. And we can build throughout the year; all we need is a few clear days.

REPP: Who buys these homes, and how do they hear about you?

replace some marble panels, the cost of the solar installation goes down.

Third, entities that expect to continue to use a structure over a longer period of time can *reduce long-term expenses by up-front investment*. While fossil fuels are cheap today, building with renewables is an insurance policy against swings in this market. Paying for the improved system ahead of time frees up capital or cash demands in the future. For all sectors of society, this serves as a long-term endowment for a sustainable future. For governments faced with long-term energy costs for maintaining schools, libraries, police stations, and other official buildings, investing in energy efficiency and renewables is a prudent approach that does not saddle future generations with high energy costs.

PART III. THE SOLUTION

Research, Development, and Deployment

In any industry, research and development are key factors to maintaining innovation and a competitive edge. But the building industry falls far behind others in its private investment in R&D. On average, construction R&D expenditures account for 0.5% of sales, with investments in housing (materials and components) and construction materials accounting for an above-average 1.7% and 1% of sales, respectively.[21] In contrast, the U.S. average for industry investment in R&D is 3.5%. This limited investment is generally attributed to the fragmentation of the industry; many companies are small, innovations in one industry segment are not easily integrated throughout the industry as a whole, and it is often unclear how the returns on R&D investments will be realized.

Publicly funded research, development, and deployment (RD&D) programs can focus on strategies for integrating the various building systems and disparate actors into a coordinated whole buildings approach. Experience from the U.S. Department of Energy (DOE) *Building America* program demonstrates the potential of this approach. Teams of architects, builders, contractors, and equipment and materials manufacturers work together to design, build, and test prototype homes that incorporate the latest innovations in green building materials, products, and systems. Production builders participating in each of the consortia determine which designs and measures will then be implemented on a commercial scale. DOE funds design expertise, training, and demonstration and testing of innovative products and techniques that builders are least likely to invest in otherwise. By requiring the designers and builders to fund construction, the program promotes development of cost-effective innovations that can be replicated on a large scale. Building America designs and technologies are being adopted and incorporated into a growing number of new homes around the country, including a portion of the more than 35,000 homes constructed by builder members each year.[22]

The Partnership for Advanced Technology in Housing (PATH) program, administered by the U.S. Department of Housing and Urban Development (HUD) with support from DOE, capitalizes on the success of Building America in promoting an integrated, whole buildings approach to home construction. Launched in 1998, the goals of the program include energy use reductions of 50% in new homes and 30% in existing homes.

DB: I've built about 20 of these homes, with another 40 on order in the next six months. Mostly to married couples, with at least one member college-educated. They're generally computer-literate. Most have an environmental interest, although some just wanted to stick it to the local utility. For some of them, it was Y2K worries that finally made up their mind. So far, I've built homes in Pennsylvania, New York, Massachusetts, and Vermont, but I have national aspirations. I'd like to affiliate with other modular builders in states with strong solar incentives.

These folks have sought me out, or heard about me through word-of-mouth. For the most part, the solar industry cannot market its way out of a paper bag, even though we have a good story to tell. I wish I had the budget to fund a serious professional advertising campaign. As it is now, builders build what they know and won't take risk, and customers don't know to ask for it. That's great for me, of course, because it leaves the field open. But more competition in a bigger market would be even better. Other builders' solar advertising would help me by boosting demand, because diligent customers will see that my products are better-designed and cost less.

REPP: Don, your innovations with modular building techniques notwithstanding, up to now we've been talking about traditional territory for solar builders: educated customers, free-standing custom homes, and so on. But you're also working on solar homes in new contexts. Tell me about the Reinhard Street Solar Townhouse Project.

Action Steps

- *DOE, HUD, and other relevant agencies* should expand their support for R&D in building systems integration strategies and implementation by industry consortia. The government should also support deployment of the technologies developed with its R&D funding through education and outreach to the building industry and consumers.

- *Builders* should support dissemination of the technologies and practices developed through programs like Building America and PATH through broader education and training of the contractors, developers, and financiers they work with and incorporation of new technologies into their production-scale designs.

- *DOE and the building industry* should work together to expand the Building America model to the commercial sector. Designing and constructing a few model buildings in each region of the country would demonstrate the concepts, techniques, and benefits of green buildings to architects, builders, and contractors nationwide. To maximize the impact of the program, DOE should monitor each building's performance and make the information widely available.

Information, Education, and Training

A significant obstacle to broader acceptance of renewables and energy-efficient technologies is the lack of awareness and understanding of the range of green building technologies and practices among architects, builders, contractors, and others in the building industry. Information, education, and training initiatives can help stimulate new construction that exceeds the levels set out in building codes.

New technologies and innovations for green buildings continue to flow out of research labs. But without adequate efforts to disseminate practical information on the benefits and appropriate application of these technologies, practitioners will stick with the tried-and-true techniques that produce wasteful and polluting buildings. In addition to information, the building trades (architects; builders; heating, ventilation, and air conditioning (HVAC) contractors; equipment installers; etc.) should receive sufficient education and training to put these technologies into place. DOE and the Environmental Protection Agency (EPA) are working to educate the building industry through the Energy Star programs for new homes and commercial buildings. DOE supports builder and contractor training through the Building America and PATH programs, but these have a limited impact due to lack of funding and other factors.[23]

Improved training and certification programs for the building trades will also contribute to establishing green building design and practice as the norm. These programs can introduce the mainstream building industry to new technologies, such as aerosol-based duct sealing, reflective roofing materials, photovoltaic shingles, and more. Furthermore, these programs can provide a means of ensuring that builders and contractors have a solid foundation in the basics of efficient building and equipment operation. For example, recent studies demonstrate the extent of installation problems for HVAC equipment, ducts, and insulation in residential buildings. Addressing these problems can produce energy savings of 20–35% in new and existing homes.[24] The North American Technical Excellence certification program is working to improve its testing and training programs to better address installation problems with significant efficiency implications, but this is a relatively new initiative.

DB: This is an interesting story. It's a great concept, and a lot of people are very excited about it—but it's been an uphill struggle.

Reinhard Street is in a lower-middle-class neighborhood in Southwest Philadelphia, bordering the University of Pennsylvania and Drexel University, near University City. It's mostly working families in row homes. There's also a sprinkling of professors in big, old Victorian houses.

The community has been fighting the usual inner-city problems: drugs, crime, and so on. One particular problem was a vacant, weedy, city-owned lot on Reinhard Street that was attracting that type of activity. A local community group, the Crusaders Development Corporation, got interested in the idea of a 24-unit townhouse project on this nuisance property. (Soon afterwards, the city revised the plan to 18 units.) After seeing a presentation I gave in autumn 1994, the Crusaders proposed that the City of Philadelphia develop solar homes on the site—and that I do the work. Eventually, the Office of Housing and Community Development (OHCD) approved a construction budget of $1.4 million.

Up to this point, I'd been building one-family homes outside Philadelphia. The costliest one I'd done was $380,000. I had no experience with projects this large, with city government, with this area—none of it. So at the suggestion of OHCD, I partnered with a successful Philadelphia builder of affordable housing, a non-profit group called Resources for Human Development.

Enlisting the building industry's active support for energy-efficient practices and renewable technologies will be pivotal in ultimately shifting the market toward green buildings. A report by Cornell University's *Work and Environment Initiative* proposes tapping industry channels of communication, training, and R&D.[25] The specific advantages of involving contractor associations and building trade unions include connection to a wide audience of workers who can promote and adopt building-integrated technologies; well-established channels of communication through Web sites, newsletters, conventions, and regional/chapter meetings; and access to training programs and facilities to speed dissemination of technologies and to develop installation and service skills and standards.

Action Steps

- *EPA and DOE* should expand their education efforts under the Energy Star buildings programs to include a greater emphasis on training builders and contractors in the full range of energy efficiency and renewable technologies and practices available.

- The *building industry* should support continuing education and training, as well as stronger certification and testing programs, for members of the building trades. In particular, programs should focus on duct sealing, HVAC installation and maintenance practices, insulation and house sealing, and other areas where large opportunities exist for performance improvements and energy use reductions.

- *Renewable energy and energy efficiency advocates* should work with *building industry trade and contractor associations* to develop and produce effective, user-friendly information and education tools to help educate building practitioners about green building technologies and practices. Green building advocates can also arrange for product seminars and exhibits at national, regional, and local contractor or union conventions and meetings. Finally, advocates should educate consumers and building owners about appropriate certifications for builders and contractors.

- *Consumers and building owners* should require builders and contractors to maintain the appropriate certifications for their trade. By insisting that practitioners meet high qualifications, consumers and building owners will build support for these programs throughout the industry.

Information, education, and training materials and programs should be integrated with the other initiatives outlined in this report. Better education and information on green building technologies and practices should be provided to the *financing community, code officials, and other building decisionmakers*.

Spurring Investments Through Greener Financing

The higher first-costs associated with renewable and energy-efficient building technologies and components create a significant barrier to building demand for green buildings. Opportunities for encouraging investments in green construction and building improvements exist in public bonding and pension funds.

Public Bonding

Thousands of jurisdictions issue billions of dollars of public bonds for construction each year. Requiring that the buildings constructed

As time went on, we accumulated other partners. Through PV-BONUS, we won up to $150,000 to purchase and install the PV panels. We became part of the DOE's Million Solar Roofs program. Meanwhile, GMAC Mortgage [a firm with over a million mortgage customers, based outside Philadelphia in Horsham, PA] had developed a solar mortgage product, which allows home buyers to fold the cost of a PV system into their mortgage, by virtue of lower utility bills in the future. In June 1998, GMAC unveiled this new product at a press conference on the site of our solar town house project. It was a big party, which also celebrated the one-year anniversary of Million Solar Roofs.

And there are other partners. For instance, the Delaware Valley Reinvestment Fund announced a special fund to help low-income employees of the University of Pennsylvania purchase homes near the campus. Our homes qualified. Here's another partner: deregulation of Pennsylvania's electric generation business has encouraged the growth of "green power" marketing in the state, and Philadelphia Electric Company (PECO) seem to want to "green up" its image. As part of a collaborative process negotiated with several local groups, PECO will contribute into a Sustainable Development Fund, and they have proposed to the Pennsylvania Public Utility Commission that they spend at least $70,000 of this fund on inverters and other solar equipment for the Reinhard Street project. So PECO is on board. The Fund has even offered to make up any shortfall in funding that we have. But I hope we won't have any shortfall at all!

REPP: So everything is going well?

A Sampling of Green Building Resources

Green Building Advisor:
http://solstice.crest.org/software-central/html/gba.shtml

ACEEE:
http://www.aceee.org/pubs/index.htm

Environmental Building News:
http://www.ebuild.com

Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division:
http://eetd.lbl.gov/

Green Building Concepts:
http://greenconcepts.com/index.html

with this money meet certain energy standards can leverage billions of dollars of projects and alter mainstream construction and design practices. The chief barrier to this concept is that some bond sellers may resist such a change, arguing that bonds represent an inappropriate and unprecedented vehicle for social concerns, or that this will raise the bonds' risk level. Yet Americans have on occasion attached social objectives to public bonding—for example, to require non-discrimination, minority set-asides, or local content. Moreover, the public nature of bonds makes it appropriate to require their use in the public interest.

Some jurisdictions have already begun to use public bonds to stimulate more energy-efficient construction practices. For instance, explicit inclusion of energy efficiency concerns early in the financing process led to improved lighting and HVAC systems in San Francisco municipal buildings.[26] Likewise, Minnesota has attached more stringent energy-efficiency requirements to public bonding of buildings. Among provisions for life-cycle costing, pollution prevention, and sustainable resource use, recent proposed legislation in Minnesota includes a prescription for "Sustainable Energy Use." This instruction mandates state officials to "when economically justifiable, reduce fossil fuel use, use less polluting fossil fuels, and give preference to local renewable substitutes in order to increase the local economic benefits and long-term reliability of Minnesota's energy system."[27]

We favor a broad reinterpretation of legislative bonding authority to establish a general policy in favor of green building techniques. When private groups or government agencies use the long-term borrowing power of the state to finance buildings, it is reasonable to ensure that they serve the long-term interests of the citizens responsible for that finance. Adding a requirement to bonding legislation or referenda that requires strong energy efficiency and renewables design is a prudent policy that will serve the public interest.

Pension Funds

Pension funds are among the country's largest property holders and investors in commercial real estate. Their activities include investing in new construction projects, holding notes on buildings, and supporting mortgages. While real estate represents only 3% of pension funds' current average annual new investments, the overall residual portfolio investment is considerable. Pension funds already

DB: Well, yes and no. Even with all these partners, it's been a real struggle to break ground on this project!

The Philadelphia OHCD is the official funder of the project; they disburse all federal, state, and city money. OHCD seems to like the project. But they rely on the city's Redevelopment Authority (RDA) to implement the project, and the RDA has been less enthusiastic. Of course, some agency people were forward-thinking folks, people of good will. And others just needed training and the proper incentives to make sense of a new idea. But others really made it difficult for us. The big problem is that people faced with something new sometimes find it easier to make no decision at all. They never actually say "no," but just keep stonewalling.

But we did find project champions, both inside the city government and outside. We supplied every item of information they requested, and the numbers proved that the project is inherently a good one. And it fits the agendas of a lot of groups.

REPP: This is pretty different from what you started out doing. Why are you messing around with local bureaucrats and government programs at all?

DB: Because this is really important. We're trying to redefine affordable housing. It used to mean that you subsidize the cost of the house, throw it up using whatever method possible, and ignore the energy cost of operating it. I want to show that with the same funding sources and the same budget, you can use sustainable energy technology to build truly affordable housing: low-cost to build and low-cost to live in.

own nearly 39 percent ($698 billion) of the $1.79 trillion of institutional equity real estate. And in absolute terms, the pension sector is large: by the end of 1997, total pension assets topped $4.9 trillion, by far the largest source of investment capital.[28]

Pension funds are typically conservative investors. In fact, legislation such as the Employee Retirement Income Security Act often requires that pension fund managers protect contributors by pursuing diverse, conservative investment approaches with substantial focus on maintaining longer-term assets. For this reason, the pension sector has a financial and fiduciary interest in ensuring that its real estate holdings retain their value. Furthermore, it has the financial weight to ensure that its insistence on whole buildings may genuinely transform the market for buildings.

Action Steps

- By legislation or referenda, *state and local governments* can mandate maximum feasible incorporation of energy efficiency and renewables into any state- or locally supported construction bond issue, with particular attention to government facilities and environmental and industrial development bond issues.

- *Government, industry, and advocates* can work together to provide training to bond-writing teams and to construction specifiers on potential areas for integration of green building technologies and practices. Builders must be informed of the best available and affordable technologies for complying with such regulations.

- *Pension contributors*, especially those who exercise influence over investment policy through their unions or shareholder action, can urge their fund managers to give preference to energy-efficient green buildings as they seek and influence properties to invest in.

- In response to contributor preferences, *pension fund officers* should create core standards for responsible pension investment that encourage energy conservation and renewable use. Pension funds must communicate these policies clearly to real estate staff and investment managers.

- *Renewable energy and energy efficiency advocates* should educate pension investors, analysts, and real estate investment managers about the value of investment buildings constructed using wise energy approaches.

Financial Incentives For Consumers

Financial incentives can play an important role in stimulating commercialization and sales of innovative energy efficiency and renewable energy technologies. While there are always early adopters with an interest in purchasing the latest cutting-edge technologies, most consumers need financial incentives to persuade them to invest in state-of-the-art products before economies of scale begin to kick in and lower costs.

President Clinton and several members of Congress have proposed tax credits to encourage the purchase of energy-efficient and renewable energy technologies. The credits would cover energy-efficient new homes and building equipment, including heat pump water heaters, fuel cell cogeneration systems, and some combined heat and power systems, solar systems, and wind and biomass power. At the state level, Maryland is considering legislation that would pro-

REPP: What have you learned from your diverse experiences as a solar builder?

DB: That sustainable housing doesn't have to be a boutique product for the rich. With modular building techniques, we can make solar homes a competitive option for the middle class. Perhaps more surprising, we can use those some techniques to make affordable solar homes for the less well-off.

With respect to affordable housing in particular, I've learned the value of persistence. You have to be relentless, and you must believe in what you're doing. Don't let the negative forces chip away at you. Just as important, you can't do it alone. Each strategic partner adds credibility.

I guess I've also seen that what you learn in the open market doesn't necessarily apply to the program-oriented world of city housing. I can imagine doing this kind of housing without public support, but in inner-city Philadelphia, there is virtually no unsubsidized housing going up. So you'd be foolish not to use the subsidies. But even so, local bureaucracies can be brutal to deal with.

I suppose the number one lesson is that it takes heroic effort by many good people. You need powerful local partners, robust community support, and—most important—courageous individuals within a Housing Authority willing to listen, learn, and act to improve the housing stock for which they're responsible.

vide state tax credits equal to 50% of the proposed federal credits. Legislation in the Maryland Senate would also eliminate the sales tax on Energy Star–compliant clothes washers, room air conditioners, and refrigerators.[29]

Financial incentives for highly efficient new homes have proved successful in the Pacific Northwest. Utilities in the region provided incentives to builders complying with a set of voluntary new standards designed to address poor construction practices. Estimated cumulative utility expenditures over the program period are $112 million, with estimated electricity savings in 2003 of approximately 1.35 billion kilowatt-hours (kWh), resulting in a cost of saved energy to the utilities of approximately 0.5¢ per kWh. Once the voluntary program was widely established, the standards were made mandatory and the incentive program ended.[30]

Energy mortgages (EMs) provide consumers with incentives to improve the energy efficiency of existing homes or to purchase a new or existing home that is rated as energy-efficient. Through energy improvement mortgages, homeowners can obtain financing to upgrade an existing home. Energy-efficient mortgages allow homebuyers to stretch the debt-to-equity ratio above maximum loan limits for energy-efficient homes or to obtain lower interest rate mortgages such as those offered with Energy Star mortgages. Lenders provide these financing products with the understanding that energy-efficient homes have lower utility bills, freeing up cash that can be used to service the energy improvement loan or the larger mortgage. Although the use of EMs has been limited, several national private mortgage companies (Chase Manhattan, Inland Mortgage, PHH, Countrywide Home Loans, GMAC, and Norwest) are providing leadership by expanding their EM offerings, and EPA has developed EM products in support of its Energy Star Homes program.[31] An expanded role for EMs exists in providing adequate financing for green buildings.

Action Steps

- *Federal and state governments and utilities* should implement a series of financial incentives for consumers and builders investing in state-of-the-art green buildings and energy-efficient products. Funding for these incentive programs can come from public benefit funds established as part of state or federal utility restructuring legislation. Incentives should be phased out as new technologies become well established in the marketplace.

- The *building industry*, including manufacturers of energy efficiency and renewable technologies, should support these incentive programs and aggressively market qualifying products to contractors, equipment installers, and consumers.

- *Advocates* from the energy efficiency, renewable energy, consumer interest, and business communities must educate policymakers about the economic and environmental benefits of green building technologies and support well-crafted incentive policies that include practical, effective means for offsetting the higher initial costs of green buildings.

- *Mortgage lenders and government-backed mortgage agencies*, such as Fannie Mae and Freddie Mac, can develop financing products to enable consumers to upgrade and purchase green buildings. *Federal and state governments*, through housing, energy, and environment agencies, should develop effective tools for rating the performance of buildings as a means to qualify green building performance.

Building Codes and Efficiency Standards

The United States, unlike most other countries, does not have a national residential building code. Rather, three professional organizations have established regional codes for housing.[32] Together, these groups established the International Energy Conservation Code (formerly called the Model Energy Code). To date, 32 states have adopted residential energy codes equivalent to the 1992 (or a more recent) version of this. In addition, the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) has established the ASHRAE 90.1-1989 model standard, which sets a standard for energy-efficient design in commercial buildings; 29 states have adopted commercial building codes equivalent to the ASHRAE model standard. The 1992 federal Energy Policy Act (EPAct) requires states to consider revising their existing residential building codes to include the Model Energy Code and to adopt a commercial building code that meets or exceeds ASHRAE 90.1-1989.

Still, I have faith. On the home-building side, I have tremendous confidence in our products. On the Reinhard Street development, I know it's a good project, which has kept us in this ball game for so long. So, we'll keep on doing whatever it takes to make this project a reality.

REPP: Thanks, and good luck.

Building codes affect energy efficiency in buildings by setting standards for lighting, electrical systems, appliances, windows, landscaping, plumbing, and other features. Codes could also insist on maximum feasible use of renewable energy to provide energy to new buildings. Yet in spite of gradual improvements and attention to energy issues in current codes, most building codes reflect neither technological progress nor the growth in energy end-uses. Tremendous opportunities remain to use codes to encourage green buildings. For example, an analysis by the American Council for an Energy-Efficient Economy and the Tellus Institute shows that adoption and enforcement of "good practice" model codes and continued improvements of these codes during the next decade would result in 26 billion kWh of end-use electricity savings and 0.29 quads of direct savings of natural gas and other fuels in 2010.[33]

The notion of increasingly stringent building codes may seem unattractive for political reasons. After all, Americans generally bridle at additional regulation. Yet governments already set building codes and regulations to protect homeowners from shoddy work, to promote public health and safety, to ensure compatible land uses, and to protect community values—with a relative lack of controversy, and often with support from both builders and consumers. For instance, codes regarding structural integrity in earthquake zones embody a precautionary principle: we consider mandatory earthquake protection a legitimate public function, even though any one building faces only low earthquake probability.

Unabated, climate change will alter and unbalance weather patterns, leading to storms and flooding of coastal areas, migrating agricultural zones, and public health risks. Adopting and enforcing stringent yet cost-effective building codes will help reduce these threats.

All new construction should aim for significant shifts in energy use and production. The fastest way to bring this about is to hold all builders to higher standards. If codes set a minimum level of practice, builders will change their concerns about added costs to a focus on how to accomplish their goals better and cost-effectively. The first step must be to get all states to adopt current "good practice" model codes. Second, attention should be focused on upgrading the model codes to account for improvements in building technologies and practices, including renewables. (See Box 3.) Finally, steps should be taken to ensure better code enforcement and compliance. Various actors can play different and important roles in promoting a higher set of building codes and standards (see also Box 4).

Action Steps

- *State and local governments* can lead by adopting renewable energy and energy-efficiency codes, such as the Model Energy Code, or by going beyond minimal requirements when they fulfill the federal EPAct requirement for building code review. With federal support, they must also provide the funding, technical support, training, and infrastructure required for the implementation and enforcement of the codes.

Box 3. Specific Priority Code Changes

Federal, state, and building codes can go beyond minimum compliance requirements to include certain efficiency or renewable features. For example, in areas where winter sunshine is abundant, a code might require building owners to obtain a certain percentage of their heat or electricity through solar design features. Land use planning codes might require solar building orientation where feasible. In northern regions, codes might require maximum insulation.[36] In all regions, codes might require wiring for renewables for all new construction and for net metering in states where it is allowed. Building codes should also incorporate requirements for improved efficiency heating and cooling equipment, increased use of lighting controls, and proper building commissioning as well as duct sealing and air infiltration requirements.

Because the current International Energy Conservation Code generally does not include such prescriptive requirements, shifting from minimum efficiency standards will take time, political will, institutional infrastructure, and awareness.[37] First, on the political side, in most states legislators do not oppose energy code changes, but they do not become "flag wavers" for energy code improvements because they choose other, more politically charged causes. Second, in the institutional arena, the EPAct provides significant funding for code review, yet in most states not enough infrastructure exists for building codes departments to raise the required matching grants. A third challenge to enacting code changes is a general awareness gap among consumers, legislators, and builders.

- The *federal government* should promote sustainable construction through enforcement of EPAct requirements. Agencies, Congress, and the administration should review existing regulations, norms, and standards, revising them to stipulate levels of environmental performance beyond mere compliance. DOE and HUD should continue to provide and expand financial and technical assistance to promote and coordinate widespread adoption of such codes and standards.

- *Grassroots and state coalitions* can promote policy statements and flexibly responsive codes to incorporate the maximum use of renewable energy technologies into building systems. Each year the International Code Council (ICC) implements a code revi-

Box 4. Existing Efforts to Develop Building Codes and Standards

The *International Code Council* is a nonprofit organization dedicated to developing a single set of comprehensive and coordinated national codes. Code development and maintenance responsibility for the Model Energy Code has been transferred from the *Council of American Building Officials* to the ICC in order to provide proper interface with other international codes.[38]

The *American Society of Heating, Refrigerating, and Air Conditioning Engineers* is an international organization of 50,000 individuals working to advance the science of heating, ventilation, air conditioning, and refrigeration. ASHRAE writes standards that set uniform methods of testing and rating equipment and establish accepted practices for the HVAC industry, including the design of energy-efficient buildings.[39]

The *Building Codes Assistance Project (BCAP)* works to promote and accelerate the adoption, implementation, and use of energy-efficient construction standards in the United States with an overall goal to reduce energy consumption in buildings. To achieve this goal, BCAP directs its efforts toward enacting and implementing effective statewide building energy codes where possible; enacting and implementing effective local building energy codes in major metropolitan areas in states where statewide codes lack support; and promoting effective voluntary energy codes where mandatory codes lack support. BCAP's strategy includes a blend of advocacy and outreach, technical assistance, and communication with a broad range of stakeholders.[40]

The *New Buildings Institute (NBI)* is a national collaborative working to encourage and support workable energy codes and design guidelines. NBI works with federal, regional, and state groups to assist and support preparation of code change proposals, target support for coordinating and implementing new building energy policy, and develop model guidelines to voluntarily promote advanced building designs.[41]

The *U.S. Green Building Council (USGBC)* is a nonprofit coalition of product manufacturers, environmental groups, building owners, building professionals, utilities, city governments, research institutions, professional societies, and universities. The USGBC is currently in the pilot test phase of the Leadership in Energy and Environmental Design (LEED) Green Building Rating System.™ LEED is a voluntary program that rates new and existing commercial, institutional, and high-rise residential buildings, awarding different levels of green building certification based on total credits earned. LEED evaluates environmental performance from a whole building perspective over a building's life cycle, providing a definitive standard for green building.[42]

The *American Institute of Architects' (AIA) Center for Building Performance* identifies and addresses relevant issues within the building and regulatory environment. The AIA has proposed that building performance constitute the major criteria for the design of buildings. In addition, AIA has been instrumental in causing the three U.S. code-issuing organizations to adopt a common format and to begin work on a unified International Building Code.[43]

The *U.S. Department of Energy* supports many code organizations at the national, state, and local level and provides technical assistance to states in adopting and enforcing codes. DOE has developed Home Energy Rating Systems (HERS) guidelines managed by the non-profit HERS Council. The guidelines rate new and existing homes on how closely they follow the requirements of the International Energy Conservation Code. The HERS guidelines let agencies that finance home purchases estimate the likely value added to a home by its energy efficiency upgrades. The purchaser of a home with a high HERS rating and a consequent likelihood of lower future energy bills may qualify for a better mortgage package.[44]

sion process, whereby every citizen has the opportunity to submit a proposal to upgrade the energy code.[34] Beyond involvement in raising the bar for codes, citizens and institutions should adopt the International Energy Conservation Code and land use codes requiring appropriate solar orientation of buildings.[35]

- *Governments and advocates* can build support for codes within the building industry by highlighting the flexibility that building codes offer. Codes allow builders to trade off measures and optimize their overall designs.

Building Support from Building Owners

Beyond the measures described thus far, it is critical to foster the enthusiasm of both contractors and consumers for green building technologies. We suggest stimulating adoption within the building industry by creating demand in specific sectors. The focus here is on government actors, but similar effort could be directed toward faith-based communities and higher education institutions, among others. Each of these sectors represents a significant market for energy efficiency and renewables, plays a leadership role in the nation, can serve as a model to builders and consumers, benefits from potentially high savings on energy bills in a reasonable time frame, and has a mandated responsibility to invest in the health, safety, and welfare of its constituents.

Federal, State, and Local Buildings

The vast stock of federal, state, and local government buildings offers an important opportunity for expanding the market for renewables and energy-efficient technologies. The 500,000 buildings of the federal government represent approximately 0.5% of the U.S. building inventory. The federal government spends more than $3 billion a year to heat, cool, light, and power these properties. Taken together, federal, state, and municipal buildings consume more than $8 billion worth of energy each year.[45]

During the past 20 years, the federal government has acted to reduce that energy bill through energy efficiency investments and the application of renewable energy systems in new and existing buildings.[46] The Clinton administration plans to use several existing tools from programs authorized by Congress for energy efficiency, renewable energy, and environmental technologies. In 1994, President Clinton signed Executive Order 12902, calling on the federal government to accelerate the purchase of solar energy power systems for federal buildings. This order was superseded in 1999 by Executive Order 13123, establishing targets for improving the energy performance of federal buildings. The order requires federal agencies to reduce energy consumption in their facilities by 30% by 2005 and calls on the federal government to install 2,000 solar energy systems by 2000 and 20,000 solar energy systems by the end of 2010. The DOE-coordinated Million Solar Roofs Initiative commits the federal government to install solar-electric and solar-thermal energy systems on at least 20,000 federal buildings by 2010. This program can be strengthened and serve as a model for state and municipal governments looking to reduce their energy bills while becoming better environmental stewards.

Some state and local governments also promote renewable energy technologies and energy-efficient practices. In Minnesota, for example, Governor Ventura is sponsoring legislation establishing the Minnesota Leadership in Economic and Environmental Design (MnLEED) project. If passed, this program would use two new buildings and two retrofits as pilots to explore the most innovative and cost-effective building design, construction, and operations practices in use worldwide. Once tested, the state will incorporate the most appropriate of these technologies into future state building projects. MnLEED proponents estimate the savings potential for the state's 4,800 buildings and 73 million square feet as $70–100 million a year.

States in the Pacific Northwest have also been leaders in promoting commissioning in new and existing public buildings in the region.

In 1993, the City of Santa Monica began a long-term energy efficiency strategy as part of the Sustainable City Program. After analyzing the energy efficiency potential of the city's residential, commercial, institutional, and industrial sectors, the city set a target of 16% reduction in citywide energy use by 2000. The savings from increased efficiency helped the city pledge in 1999 to purchase only green power—the first city in the nation to do so.

The Austin Green Building Program provides a voluntary sustainable building rating for residential and commercial buildings and an education program for builders, architects, and homeowners. The program has provided energy and cost savings to the city-owned utility and its customers, has helped establish a market for a green building industry in Austin, Texas and serves as a model for municipal green building programs around the country.

Action Steps

- The *federal government* should go beyond President Clinton's pledge to install solar systems on some federal buildings to incorporate the full range of available renewable energy technologies and efficiency measures for both existing buildings and new construction.

- When renting office space, the *federal government* should seek space in green buildings that minimize rent and operating costs over the long run.

- *State and municipal governments* should incorporate energy-efficient practices and renewable technologies when retrofitting old buildings and constructing new ones. Existing state laws calling for sound energy and environmental building design often go unheeded; efforts should be made to reverse this lax record.

- *Citizens and advocacy groups* should demand that government agencies at all levels invest their tax dollars in energy-saving and energy-producing approaches and insist that all new construction incorporate best practices in efficiency and renewables.

- *The building industry* should work with government and citizens to estimate costs and install these technologies with quality assurance.

Schools

School districts spent more than $15 billion in 1998 on construction.[47] The total energy bill for K-12 schools in the United States tops $6 billion annually. Wasted energy shortchanges students and teachers alike, not only in terms of cost but also in terms of discomfort, sickness, and lost productivity. One energy-saving measure, daylighting, has even been shown to improve student test performance.[48] By making our schools more energy-efficient and by adopting renewable technologies, schools can save $1.5 billion by 2010—enough to buy 40 million new textbooks or hire 30,000 more teachers.[49]

The federal government, in partnership with local stakeholders, is working to achieve those savings. EnergySmart Schools, a White House initiative coordinated by DOE, promotes increased energy efficiency and use of renewable technologies in new and retrofitted schools. The initiative seeks to work with partners at all levels of government, community groups, school personnel, building professionals and crafts people, and others to cut energy bills and reinvest the savings in education. The program serves as a model for how the government and its partners can bring about wider-scale adoption of energy-saving technologies on other types of government buildings.

The Alliance to Save Energy's Green Schools program brings together students, teachers, custodians, administrators, and community partners to combat energy waste in schools through building retrofits and changes in facility operations and maintenance. The program also goes a step further to address the behavior of school building users in all aspects of their life through incorporation of energy efficiency concepts throughout the school curriculum.

Action Steps

- *Local school boards and municipal budgets* should plan for the long term by insisting that all new schools incorporate the largest amount of efficiency and renewable energy even at higher initial construction costs, since these investments will be recouped over time.

- The *federal government* (including the Department of Education and DOE), *state agencies, and local school districts* should go beyond mere promotion to mandate the adoption of the green buildings approach at schools, incorporating renewables broadly.

- *Students, teachers, staff, building maintenance workers and their unions, along with citizen groups* should play an active role in these efforts through advocacy and partnerships with the federal government.

- *Advocates and the building industry* should work together to provide school districts and facilities staff with knowledge and tools for implementing effective green energy technologies throughout their facilities.

- The *building industry* can work with school districts and state and federal agencies to assure quality installation and maintenance of "green" schools.

Military, Public, and Native American Housing

More than 350,000 families live in U.S. military houses—most of which were built 20–40 years ago. DOE's Oak Ridge National Laboratory (ORNL) has found that because the government pays the utility bills for these inefficient structures, tenants have low incentive to conserve energy. Taxpayers pay for this waste. A range of measures can remedy this burden on finite energy resources and tax dollars while housing the nation's military and their families in greater comfort.

President Clinton's Executive Order 12902 mandated that the military reduce its energy consumption by 30% by 2005 compared with 1985 consumption.[50] In the area of education, ORNL is currently working with the U.S. Army and the U.S. Air Force to improve efficiency during current efforts to meet new housing needs, provide housing quality comparable to that found in the private sector, and meet reductions in energy consumption mandated by the 1992 Energy Policy Act.

Public and Native American housing offers another promising path for expanding the scale of renewables and energy efficiency practices.[51] Public housing authorities across the nation operate some 3.1 million units.[52] The HUD Inspector General reports that the nation's public housing authorities spend more than $1.1 billion a year—27 percent of operating costs—on utilities.[53] This sector represents a ripe potential market for renewables and energy-efficient construction. Equally important, it provides a path to redress a long-standing burden on poor families.

Low-income households—those with incomes below 150% of the poverty level—spend proportionally more on energy bills than richer families.[54] According to a 1995 study by the Energy Information Administration, middle- and upper-income households generally spend 5% or less of their total household income on energy bills, excluding transportation fuel. Low-income families, in contrast, spend 10% or more, and the poorest up to 20% or more.[55] In addition, the U.S. Bureau of the Census determined that about 10% of the population, approximately 23.3 million households, did not pay their full gas, electric, or oil bills in 1995.

Separate from the state programs noted above, federal and state agencies established low-income energy programs for electricity and other

fuels after the 1973 oil crisis, both to address equity issues and to reduce the cost to fuel suppliers of collecting overdue bills. (See Box 5 for an example of a municipal program.) For example, the U.S. Department of Health and Human Services' Low-Income Energy Assistance Program and DOE's Weatherization Assistance Program grew out of a recognized need to help families pay their household energy bills. Approximately 4.3 million households qualified in 1996 for federal assistance to meet heating costs.[56] By 1996, the federal government, state agencies, utility ratepayers, and others paid $1.8 billion in support of these programs. Action to improve the energy performance of low-income housing can lower long-term taxpayer costs and stimulate production of affordable renewable applications aimed at this market.

Federal policymakers can strengthen these programs in ways that enhance their original purpose and functions. These programs drain government and consumer coffers: by 1996, the federal government, state agencies, utility ratepayers, and others paid $1.8 billion to fund these programs. The programs were developed before the recent move to restructure the electrical industry, and so may not be able to protect low-income consumers from the uncertainties of the new utilities market. (See Box 6.)

In short, instead of subsidizing profligate and polluting energy use, an enlightened energy policy would reduce it, contributing to the national good as well as that of individual families in need. Programs like DOE's Weatherization Assistance Program partially address the need to reduce energy use in low-income housing, but greatly enhanced and expanded efforts are needed.

Action Steps

- In addition to the Clinton administration's mandates, the *Department of Defense, DOE, and other relevant government agencies* must intensify current energy-efficiency programs to incorporate renewable technologies in retrofits while building efficiency and renewables into all new military housing.

- *Federal and state governments and local housing authorities* should ensure that new military, public, and Native American housing is reasonably exemplary in terms of energy use. The buildings should be energy-efficient and use renewables where cost-effective (that is, with a payback of less than 10 years).

PART IV. SUMMARY AND CONCLUSION

Many of the technologies allowing a transformation toward green buildings, which use energy efficiently and incorporate renewables where feasible, are already available. Yet much remains to be done to transform the building market so that energy efficiency and renewable energy become standard practice.

We believe that there exists a strong role for public policy in promoting this market transformation. Building codes, expanded RD&D, financing tools, education and training, and financial incentives are places where governments can further the public interest in green buildings and jump-start the market.

Real growth will require stimulating demand. We have identified several sectors that constitute potential markets for green buildings through their focus on the long-term interests of citizens, parishioners, students, and members. Yet we will only achieve market transformation through a constructive, genuine, and cooperative dialogue between the construction industry, government agencies, occupants and owners, and other stakeholders. With full participation by all, the view backwards from 2050 will seem as strange to our grandchildren as the streets of Chicago in 1894 seem to us today.

Box 5. The Chicago Housing Authority: A Model for Low-Income Energy Programs

The Chicago Housing Authority (CHA), whose 40,000 low-income housing units constitute the second largest housing authority in the continental United States, is working in partnership with the DOE's Rebuild America program to increase energy efficiency and reduce greenhouse gas emissions.[57] Because energy usage for heating averages a relatively high 30 Btus per square foot per heating-degree day, the CHA has established a goal of reducing energy usage by 30% in half its housing stock, or 15% overall, by 2000. To accomplish this goal, the CHA has allotted roughly $15 million for energy measures that are expected to generate more than $25 million in utility cost savings. The project will improve one-fourth of the residential units and three of the CHA's administrative facilities. Nevertheless, the CHA program does not include renewable energy technologies.

Recently, the CHA announced a $1.5-billion agreement with HUD to demolish 51 decaying high-rise public housing developments containing 16,000 apartment units. Approximately 25,000 new or rehabilitated replacement units will be built, largely in low-density, townhouse developments. This vast redevelopment plan presents CHA with an opportunity to build on its commitment to improve the energy performance of its residential units by incorporating green building technologies throughout the new housing units.

Box 6. Electric Utility Restructuring: Implications and Opportunities for Green Buildings

Traditionally, utility customers have funded various "public-benefit" activities through their utility bills. Programs supported through these funds include efforts to reduce energy consumption (energy efficiency or demand-side management programs), support R&D on renewable energy and energy efficiency technologies, assist low-income customers, promote the use of renewable resources, and support environmental protection efforts. Funding for these programs has been included in customer utility rates, and program management usually fell to the utilities, with oversight from the state public utility commission.

As restructuring of the electric utility industry introduces competition into the electricity market, utility spending on public-benefit activities has decreased. Utilities are finding investments in these programs increasingly difficult to justify from a business perspective. To address the need for ongoing support of public-benefit programs, most states have included funding provisions for these efforts in their restructuring legislation and proposals. The Clinton administration also has included public-benefits funding in its proposed federal restructuring legislation.

To date, the final restructuring legislation and proposed restructuring plans of the 22 states that have moved most rapidly on this include provisions for average annual spending on energy efficiency and renewable energy of more than $1.1 billion.[58] Additional funds have been earmarked for R&D and low-income energy programs. The Clinton administration plan would provide additional matching funds to states of 15% (up to $3 billion a year).

Utility public-benefit programs have played a key role in supporting investments in building weatherization, high-efficiency equipment and building components, improved building design, and commissioning by providing education, training, funding, and incentives to building owners, consumers, and members of the building industry. Successful initiatives should be continued and expanded using the state public-benefit funds and matching federal monies. New initiatives should be directed toward increasing the market demand for integrated green building design and greater use of energy efficiency and renewable energy technologies. Public-benefit funds could effectively support RD&D activities; information, education, and training initiatives; and financial incentive programs.

2 The authors thank Don Aitken, John DeCicco, Howard Geller, Roby Roberts, Virinder Singh, Michael Totten, Carl Weinberg, and Jean Wilson for their comments on early drafts of this report. The opinions expressed here are the authors' and do not necessarily reflect positions of reviewers, REPP, or the REPP Board of Directors.

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